

## REDESIGNING ENGINES, NATURALLY

High performance, low emissions and solid business prospects.

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**An emerging technology company based in Vancouver, Westport Innovations Inc. is poised to capitalize on a growing demand for its alternative fuel vehicle technology. With a patented engine design combining the fuel efficiency of diesel engines with the environmental advantages of clean burning gaseous fuels, Westport is promoting a line of products that offer both superior performance and reduced environmental impacts.**

On the leading edge of sustainability thinking, Westport has integrated reduced ecological impacts directly into its main design focus. The result? A product with markets of well over two billion people, and the potential to be a successful demonstration of “leapfrog” technology (see sidebar p.13), a business innovation that enables less developed nations to avoid adopting environmentally destructive technologies, while benefiting from a new product innovation.

### From lab bench to startup

As many emerging technology firms, Westport’s story begins on a university lab bench. Motivated by concerns over deteriorating air quality and armed with a natural curiosity for internal combustion engines, Dr. Philip Hill, a mechanical engineering professor at the University of British Columbia, began designing a new heavy vehicle engine that uses a cleaner burning fuel. Determined to match conventional diesel performance using natural gas, Dr. Hill quickly accelerated his initial research from theory to prototype. With first test results showing promise, Westport Innovations Inc. was incorporated in 1995.

The company has quickly grown to take on a staff of 200 employees, 90% of whom work in research and development and technical support. This team is focused on one goal: the successful commercialization and marketing of high performance engines that run on low emission gaseous fuels.

Still passionate about his work at age eighty, Dr. Hill in his position as Westport’s senior scientific advisor, provides guidance and leadership to many of Westport’s less experienced engineers. He continues to contribute to academia as well, with cutting edge thermal studies research at University of British Columbia (UBC) laboratories, and as a professor in the Faculty of Mechanical Engineering. In the classroom, Dr. Hill is training an elite group of

engineers to build Canada’s future intellectual capacity, a responsibility he takes very seriously.

As David Demers, President and CEO of Westport Innovations states, “The initial research conducted by Dr. Hill and his team of graduate students at UBC was the genesis of our company’s leadership in developing and commercializing low emissions, environmentally-friendly engine

systems. Today, Westporters continue to draw inspiration and guidance from Dr. Hill’s design and technical brilliance.”

### Best Minds

Instilling a passion into the next generation of design engineers may prove to be Dr. Hill’s most significant contribution to the sustainable transportation movement. And while his leadership and dedication to research serves as a beacon to the alternative fuel vehicle cluster at UBC, his university work is helping to draw some of the best engineering and design minds to the company he began less than ten years ago.

Westport now attracts some of the best talent in engine design. It employs many British Columbia Institute of Technology instrument technologists, as well as science and engineering co-op students and graduates from several Ontario and BC universities. Other Westport employees started their career working on the development of hydrogen fuel cell technologies, another emerging industry with strong roots in UBC and the Vancouver area.

In addition, Westport has attracted

Westport technician installs a Westport-Cycle™ injector into a heavy-duty engine. Photo: Westport Innovations Inc.



committed and talented engine design professionals from around the world. The company has been able to mould this talented and diverse workforce into a highly skilled and dynamic creative team. Westport's employees must apply the fundamentals they learned in academic institutions while calling into question many conventional engine design and alternative fuel combustion assumptions. Many of these employees say they wanted to work at Westport to apply their technical skills and to contribute to a positive initiative that could improve environmental conditions in both the developed and developing world. Karen Hamber, Westport's Manager of HSE and Community states:

**“With Canadian Business for Social Responsibility, we conducted a survey on our employees’ levels of engagement with the concepts of corporate sustainability. The responses were a clear indication that they want to work for an organization whose values are aligned with their own. We see this in our employees’ passion for environmental sustainability and in our own corporate commitment to the protection of the environment, reflected not only in our product line but also in our internal operations.”**

Westport's smaller size allows employees to champion their own good ideas.

In such a fast-paced environment, there are constant pressures to find solutions to problems quickly. Employees often take leadership roles in finding the right solution rather than the “quick and dirty” answer. In this way, Westport's smaller size makes it much more maneuverable, and a champion with a good idea can improve processes with benefits across the whole company.

### **The Problem with Diesel**

What was to become a natural gas engine with a high level of performance began as a realization that diesel use is problematic. The workhorse of the global economy, the diesel engine is extremely powerful and reliable, and provides good fuel economy. Its big downside, however, is that it releases a variety of noxious substances into the air, including nitrous oxides, particulate matter and carbon dioxide.

One Westport design advantage is in its patented Westport-Cycle™ high pressure direct injection (HPDI) technology. With direct injection of a natural gas and diesel fuel mixture (approx. 95% natural gas),

combined with a unique compression ignition system, a Westport heavy-duty truck engine will release: 60% to 70% less particulate matter, 40% to 50% less nitrogen oxides, and almost 20% less carbon dioxide than comparable diesel fuel engines. Looking beyond the improved environmental impacts, laboratory tests have confirmed the Westport-Cycle technology's ability to achieve high thermal efficiency, diesel-like power and torque capability. Road tests have confirmed the engine's performance, demonstrating attractive fuel economy, and even (potentially) reduced operating costs.

Another major strength in Westport's design is the adaptability of its technology to different low emission fuels. Compressed natural gas, liquefied natural gas, propane and hydrogen can all be used with Westport technologies. Large engine manufacturers are already testing Westport technology in their hydrogen internal combustion engine programs. In fact, by introducing technology that enables internal combustion engines to burn natural gas and hydrogen fuels, Westport is creating products that have the potential to bridge today's emerging eco-efficient technologies with the eco-effective technologies of tomorrow.

### **David Joins Goliath**

To meet its goal of successfully marketing a new engine design in the diesel market, Westport collaborates with numerous industry players. The most advanced relationship is a joint venture formed in 2001 with Cummins Inc. a global company with 75 years experience in diesel engine production. Cummins provided the younger company with access to a large existing customer base and manufacturing and distribution channels. The joint venture with Westport allowed Cummins to gain access to the promising Westport technology and the potential to grow the alternative fuel market with an innovative and dedicated young firm.

Despite the difference in size and experience between the two companies, the alliance of this David and Goliath is proving to be synergistic in many ways. Westport has maintained control over its intellectual property while securing access to Cummins manufacturing capacity, distribution network and the benefits of the powerful Cummins brand, known worldwide for quality products in a market driven by performance. Furthermore, Cummins contributed its existing spark-ignited natural gas engine line to the joint venture. These engines are currently being sold around the world, laying the groundwork for the

potential higher performance Westport-Cycle™ technology. Already, the Cummins name is proving to be a critical asset, countering perceptions among the mainstream trucking industry that natural gas engines cannot provide expected levels of performance.

On the other hand, Cummins has gained access to Westport's technology and capital (Westport is funding the joint venture development work for the first three years). And Cummins employees have the additional advantage of getting to work in close collaboration with a small, dynamic and quick-to-market company solely focused on alternative fuel technologies, and with a vision to really make a difference in the world.

### **Overtaking market leaders**

Westport is changing pre-conceived market perceptions about inferior quality of natural gas engines compared to diesel. But it is not the first company to deal with entrenched market perceptions of inferior quality. In the 1980's, personal computer makers had to defend the value of their product over the seemingly irreplaceable and widespread mainframe computer. Business strategist Clayton Christiansen introduced the term “disruptive technologies” in 1997 to describe technologies with poorer initial performance that provide a unique value to a small market. As that small market grows and product performance improves, Christiansen warns that successful businesses can completely lose their market share to what they dismissed as a fringe product. Alternative fuel engines may now bring unique value to a variety of markets as a sustainable technology with equal performance. As the cost of the alternative fuel engines continues to decrease, they have the strong potential to displace traditional diesel engines in the wider market-place.

### **Fully integrated solution**

Westport is actively targeting natural gas engine markets not currently being aggressively pursued by many larger diesel engine manufacturers. The company is initially promoting its current spark-ignited products in specific markets where it could derive a significant competitive advantage. Areas with mandated lower emissions levels are attractive because it is more difficult for manufacturers of conventional diesel engines to compete there. In some markets, incentives are paired with the introduction of strict environmental legislation. Abundant natural gas and a growing transportation sector are two other factors which favour a market entry by Westport.

## Disruptive Technologies

**In general, a disruptive technology, also known as “leapfrog” technology, significantly alters its industry sector or changes it fundamentally so that previous competitive and business rules no longer apply. The phenomenon was described by Joseph Schumpeter as “creative destruction.”**

In the context of sustainability, disruptive technologies replace materially intensive, polluting or otherwise unsustainable technologies or modes of production. For example, village cell phones in Bangladesh effectively “leapfrogged” over traditional copper wire systems that were materially intensive and unable to reach remote locations easily. Fuel cells, micro-turbines, photovoltaic cells and other sources of renewable energy are examples of disruptive technologies that have the potential to replace hydrocarbon-based sources of energy and fundamentally reshape the energy sector.

Indeed, two leading business academics, Stuart Hart and C.K. Prahalad, argue that developing country markets can play a crucial role in incubating and developing disruptive, sustainable technologies because they often do not have to overcome the inertia of extensive infrastructures committed to previous generations of technology (ie. copper wires, network of gas stations or investment in coal-fired electrical plants). Then the new sustainable technologies can be introduced into the industrialized world to solve the environmental and social challenges of sustainability.

In these potential markets, Westport is working closely with fuel providers to offer customers in the transportation sector a fully integrated solution.

Many commercial vehicle users in California, a jurisdiction with some of the toughest vehicle emissions legislation in the world, have adopted natural gas spark-ignited engines from customers including the Long Beach municipal government and the Los Angeles Metropolitan Transportation Authority. Pierce Transit in Washington State is also a champion of the Cummins Westport products.

**“The C Gas Plus is head-and-shoulders above the other natural gas engines in our fleet” says Ron Shipley, VP Maintenance for Pierce Transit.**

But Westport is not only looking to North American and European markets. It also sees huge potential for its product worldwide, particularly in Asia.

According to Ian Scott, Westport’s Director of Strategic Planning: “Beijing has more than two thousand natural gas buses in operation today, all powered by Cummins Westport engines. During the past year or so alone, Westport has expanded sales outside of Beijing to seven other cities across China. The 2008 Summer Olympic Games to be held in Beijing will allow China to showcase this example to the world.”

### Targeting Poor Nations

There is enormous potential for Westport’s product in the developing world, where over two billion people survive on annual incomes of less than 1,500 USD. Few new products are specifically designed for the world’s poorest population and multinationals largely ignore this market.

The Westport technologies show significant potential for these low-income countries because these markets often have pollution and mass transportation challenges, but also have abundant supplies of natural gas.

As Ian Scott observes: “Seven of the world’s ten largest cities are in the emerging economies of China, India, Mexico, Brazil and Bangladesh. All five countries have serious air pollution concerns. All five also have abundant natural gas supplies. By powering commercial transportation with clean natural gas, these nations are able to reduce air emissions, reduce energy security risk and increase income per capita by freeing up domestic oil production for hard currency sales in international markets. The average citizen can realize significant

social and environmental benefits.”

With their responsive corporate culture, Westport can also meet the unique needs of a market such as China in a way that more established firms cannot. Westport has encouraged its employees to question assumptions in conventional engine design, and its marketing team is also encouraged to rethink conventional strategies. Westport is actively pursuing contracts in developing countries and it is willing to collaborate with both NGOs and local firms to provide a complete and sustainable customer solution.

### Beyond Engines

Westport is currently focusing on the heavy-duty automotive industry, but also sees new opportunities almost everywhere the diesel engine is used. In the future, Westport Innovations Inc. hopes to see its technology adapted for use in a wide variety of products from electrical power generators to rail locomotives. With markets stretching from Los Angeles to Beijing, Westport has become a global player in alternative fuel technologies – proving that sustainable design can provide the foundation for a solid business strategy. ●